4π Working Group Meeting on September 22, 2003: Minutes, Questions, and Answers

December 9, 2003

This note summarizes the questions and suggestions raised at the 4π working group meeting on September 22, 2003, in Sendai. It includes responses from the Berkeley group (*in italics*). It is compiled to serve as a basis for further discussion.

(For reference, the current design of the 4π off-axis calibration system is described in the Technical Design Document v0.3. Please see http://kamland.lbl.gov/internal/4pi/.)

1 Principal Questions and Concerns

1.1 Cabling

Kevlar webbing raises concerns about its radioactive content, possible leaching of radioactivity, and also the potential of trapping radon, due to large, woven surface area. The following suggestions were made:

- Perform extensive cleaning and checking of kevlar webbing.
- It may be better to use something else - carbon fiber webbing? nylon coating?
- Possibly mark the cable (check distances)
- Check for possible expansion of the polyurethane tubing.

We now have a different cable design which consists of 8 strands of stainless steel wire rope, 7 teflon coated conductors, and monofilament in between to provide the 1" width. Because it is not composed of fibers like the kevlar, the amount of surface area is greatly reduced, and it will be much easier to clean.

We will have some visual indicators on the cable for position reference. These may consist of crimps on the stainless wires of the cable. Crimps in combination with string(s) woven into the cable at the crimp points as distance markers will signify to the operator the length of the cable.

With respect to the second point, carbon fiber webbing has been considered - it was surprisingly fuzzy and very elastic.

With respect to the fourth point, polyurethane tubing is not being used in the present design.

1.2 Glovebox

- Stability - because the glovebox is on top of the long 6" spool, its possible for the pole in the detector to move or swing if the glovebox is bumped. Something needs to be done to make the glovebox more stable. Some suggestions:

  1. Support from crane rail
  2. Support from top of vessel - holes would need to be made for support beams to go through the chimney deck. Also, this support would somehow have to rotate, may require rotary stage inside glovebox.
  3. Remove or replace 6" spool with 16" spool. Also requires another method of rotation. Using a rotary stage in the present glovebox is not possible now due to space constraints.
  4. Have a strict calibration protocol which requires no one is allowed on the deck once the last segment is attached and the deployment begins.
  5. One method of testing the effect of glovebox instability on a deployed source is to deploy a central LED and observe its motion using the cameras as one pushes on the glovebox. This could be done at the time of the high voltage upgrade.

  We have concept designs for a support rod from the bottom of the crane rail to the top of the glovebox addition. The attachment at the glovebox is made using a rotating bearing which allows glovebox rotation while still providing the required stability. This will provide lateral stability, and is not intended to support or add to the glovebox weight. It may also be useful to establish a protocol to limit access to the glovebox at the time of deployment, such as is done currently with z-axis deployments. Concerns were raised by members of the calibration group about the LED swinging test due to possible interference with the presently deployed thermometers. It is recommended to remove the thermometers prior to pole deployment.

- Cleanliness - the present glovebox is not completely air tight. Because the 4π system will have the 16" and 6" gate valves open for long periods of time it is an issue for radon contamination. Some suggestions:

  1. Running very slight overpressure of nitrogen during deployment
  2. Minimize leaks
  3. Replace the glovebox
  4. However, the longest calibration so far was 15 hours and it did not produce any problem with radon. Radon problems were introduced with the deployment of the optical fiber and the AmBe in the polyethylene moderator. This echos the concern with introducing radon from the cables.

With respect to point 3, it is not a practical solution in terms of time and cost to replace the glovebox. As mentioned in point 4, we have not seen that the glovebox leaks are significant with respect to the regular z-axis deployment. Also, the current project of replacing the mine air with external air will reduce the overall radon content in the dome area.

- Other glovebox issues:

  1. Acrylic may be transparent to absorb radon (especially too thin). Possibly an optically transparent film which is not transparent to radon can be put over the acrylic.

     Adequate purging of the glovebox during deployment should prevent radon from permeating the acrylic. It is possible to make quantitative measurements of a noble gas through acrylic, although these tests may not yield conclusive results with respect to radon.

  2. Acrylic attracts dust, is hard to clean. Maybe replace with titanium or stainless steel. Does it have problems with electrostatic charge?

     If this is a problem we can implement the use of a de-ionizing fan in the clean tent area.

  3. The acrylic glovebox enclosure should be protected from contact with titanium tubes to prevent breaking or cracking which causes small chips to fall into the detector.

  4. The glass window should be replaced or protected from breaking (maybe from a pole segment).

     We are designing an acrylic replacement for this window.

  5. Everything should be checked to be ok for a gloved operator to handle, especially when oily. (Run through of disassembly with gloves on)

  6. With regards to transparency, it was noted that everytime we have to do a radial change (and possibly ϕ change) we will need to turn off the high voltage. This should be accepted by the collaboration.

     It may be possible to do the phi rotation without introducing light. One method of keeping light out would be to use the infrared glovebox camera for viewing operations when the high voltage is on.

2 Other Suggestions:

- Do a vacuum check to be sure segment welds do not have pinholes.

  We will check that the segments are adequately clean and free of the possibility of contamination.

- Possibly the current source preparation area can be used (and improved?) for 4π assembly.

- The fire marshall needs a written document about the system from Koga-san and Shirai-san.

- Keep the programming simple.

  Agreed, as long as it fulfills the safety requirements.

- The first two segments inserted into the pinblock should have a longer internal cord. This connection between two segments will be made before the hoist is disconnected.

  A variety of methods for additionally securing the first few segments are being considered.

- Discussion of the ϕ rotation: how accurately do we know the ϕ position?

  The position of the rotating stage will be driven by a servo (or possibly stepper) motor. The accuracy will be determined by the programmed motion of the servo through the controller. With 4000 steps per rotation the accuracy of the motor position can be 360/4000°. A reference point will need to be established for ϕ =0. For the analysis of the calibration data, the off-line position reconstruction of the LED's will give us a set of (x,y,z) coordinates or (r,θ,ϕ).

- Will rotation cause spinning, tangling, or turbulence if the pole is hanging (in vertical) in the detector? Should this be done with the weight end segment retracted and secured in the pinblock (no disassembly required)?

  We intend to make all motions of the pole at a very low speed, i.e. 1 cm/sec. The phi change will be done in an optimal geometric position to avoid any complications. Under these circumstances we do not foresee a possibility of turbulence, spinning, or tangling.

- Do a full scale test in water (Berkeley or Hawaii). This will give us a chance to observe the pole behavior in a liquid before deployment in Kamland.

  We have been considering the merits of a full scale water test. However, it does not seem feasible to do this test due to the infrastructure required for the deployment hardware. Also, the possible interference of atmospheric conditions in an open pool would make the test results questionable at best. Following preliminary discussions with Christopher Mauger we propose a phased commissioning plan that will allow the final testing of the functionality of the hardware in-situ without endangering the detector. The idea is to test the functionality of the deployment hardware, the off-axis pole, as well as the control and monitoring systems separately before deploying the entire calibration device into the detector.

- Do testing (at LBL) with the pole immersed in a longer pole (longer than the distance to be deployed in Kamland) filled with oil. We can test the following:

  1. First test of accuracy of pressure transducer (beyond the depths of what is needed). Second test can be done in Kamland.
  2. Test the turbulence in the scintillator.
  3. Observe bubbling if any during deployment/filling of tube. Adjust velocity to minimize.

- Test motor housing seals by soak test

- Make and send videos, videotapes from several angles, people in cleanroom gear, gloves, etc., as close to the real thing as possible.

- Have people in clean gear assemble the whole thing, deploy it in oil, retract the top segment, and replace the weighted segment (with gloves on).

At LBNL there is no space for a test with a KamLAND-sized tube. Getting approval for such an oil test would be difficult. However, we may try to test the operation and handling of selected parts in oil (such as the pivot block, in block, hoist, and a few segments.) by suited and gloved operators. We would like to make sure these operations can be done under a KamLAND type environment. In addition, we may consider constructing a horizontal trough filled with water to test damping effects.

We plan to test the pressure transducer in deep water prior to its calibration in KamLAND. It is rated for an accuracy of 1 cm, and we have no reason to believe the manufacturer's specs are incorrect.

2.1 Cable Connections

- Suggestion was made to run a second cable from the glovebox through the pole and back up again. This is for a back-up for cable and pivot block connections, but is very difficult.
- Test in a liquid over time
- Test possible cable end sealants - double bubble - test, 2 part epoxy (autocoat?)
- Cable- test to make sure no slipping on pulley
- Reduce friction of pivot block - add pulley, teflon maybe not so good because it is soft and may wear down, particles

This second cable suggestion would be very safe but is very not possible. Agreed the cables and connections need to be tested. An idler pulley is added to the guide pulley to keep the cable from slipping. This will also be sufficiently tested (and tested with an oiled cable as well). A teflon roller has been added to the pivot block design.

2.2 Material Qualifications

- All materials need to be tested to some extent, even pre-approved materials.
- Because the 4π system will have a lot of surface area, contamination is of major concern.
- Establish and test cleaning procedure for all parts (high-vac standards)
- Procedure for cleaning inside of tubes.
- Test absorption of radon in materials (cabling, acrylic)
- What are acceptable levels?
- When and where to do tests?
- Procedure for qualifying materials.
- Specific comment about titanium - is the concentration level (2.7ppm) of potassium acceptable? Is it K40 or any K? It is not a problem as long as the titanium is stable in LS.

We are working with the on-site personnel to establish these procedures for testing and acceptability. In establishing materials testing procedures, it should be noted that the requirements for approving materials only used in the glovebox are different than what is required for submerged components.

3 On-site commissioning:

- Manpower requirements, scheduling, what is needed?
- Bring Berkeley people , practice installation procedures in Berkeley

Please see the on-site system commissioning plan for details, as written in the technical design report.

4 On-Site Work in the Near Future:

- Materials testing
- Testing of pressure transducer (verify position accuracy/calibration)
- Glovebox tests, sealing
- LED tests

A in-situ pressure transducer test would require major changes to the present system deployment system in KamLAND. A method for deploying the cable with electrical and power signals, installing the feedthrough connections for the transducer, and qualifying and testing all involved materials are required. We plan to do a water test in Berkeley to verify the manufacturer's specifications. An in-situ calibration of the pressure transducer is part of the commissioning plan.